Multi-Resolution Model Integration:

Why is it Important and how to make it Work?

Dynamic Traffic Assignment – TMIP Webinar #3

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Outline

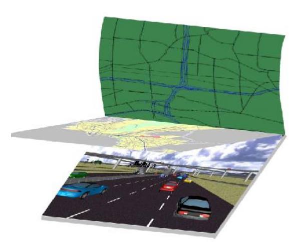
- Introduction
- Concept –Meso to Micro
- Conversion Process
- Calibration
- Consistency
- Case Study
- Other Issues
- Applications
- Concept –Macro to Meso

Introduction

- Model integration at various levels of resolution can be advantageous over traditional methods
- Planners use TDM
- Traffic engineers use micro-models
- DTA models fall in between both TDM and micro

Introduction

- Model integration takes the strengths of all models
  - TDM gives blueprint of network and provides O/D
  - DTA model provides region-wide estimation of traffic redistribution
  - Micro- local operational analysis (individual car/lane)



Concept – Meso to Micro

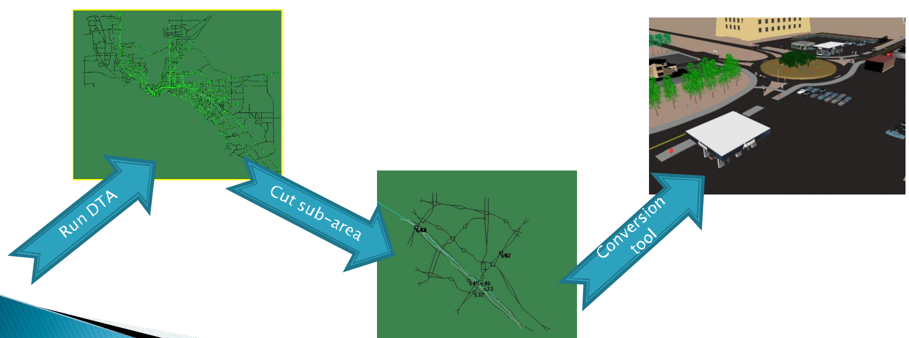
- What is multi-resolution modeling?
  - Integrating mesoscopic and microscopic models for the purpose of achieving a specific goal
    - Analyze network at both the system-wide and localized levels
- Why is multi-resolution modeling so important?
  - Mesoscopic & microscopic models are not mutually exclusive
  - They are complimentary to one another and can accomplish optimal modeling capabilities.
  - Retain the best characteristics of both
    - Realistic representation of regional traffic
    - Detailed interactions

Concept – Meso to Micro

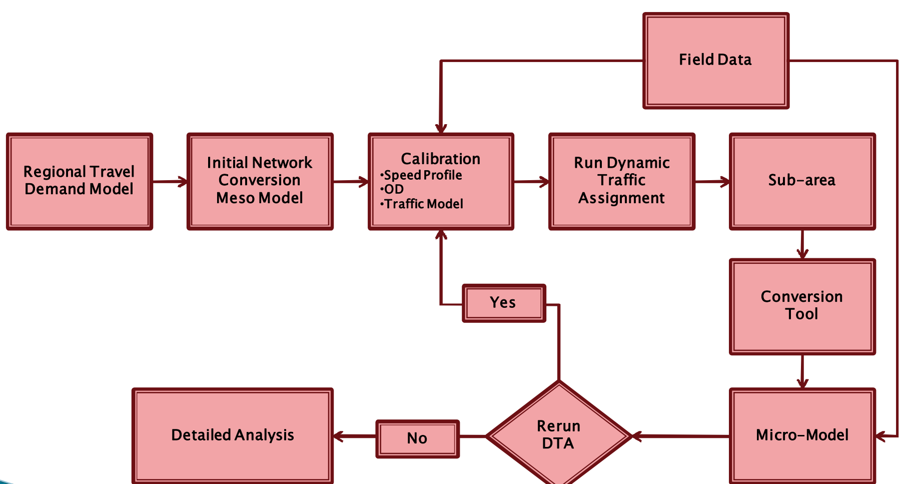
- Addresses issues that may fall beyond the reach of both:
  - Macroscopic models: large scale but static
  - Microscopic models: dynamic but small-scale
  - SBDTA – dynamic and large-scale
- The scenarios of interest may result in shifts of network or corridor-wide traffic flow patterns
  - Significant change to roadway configuration
  - Certain corridor management strategies

Concept – Meso to Micro

- Meso to Micro
  - Used for operational planning where sub-area of DTA model is converted to microscopic

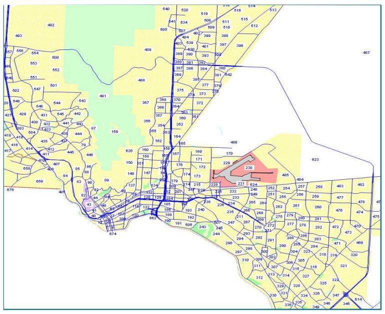


Network Conversion



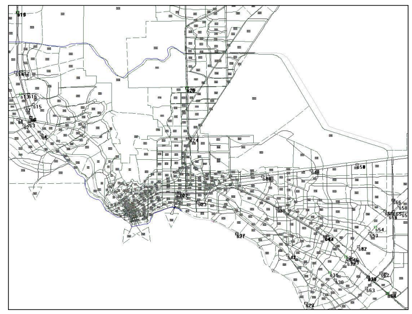
Macro -> Meso -> Micro

Network Conversion



TDM

Links
Nodes
Zones

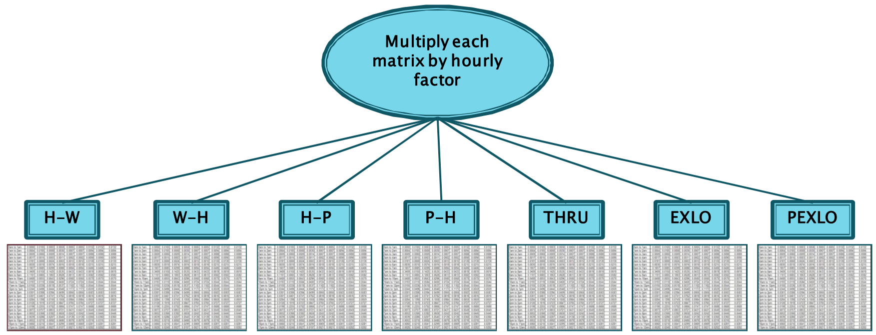


DTA model

Network Conversion

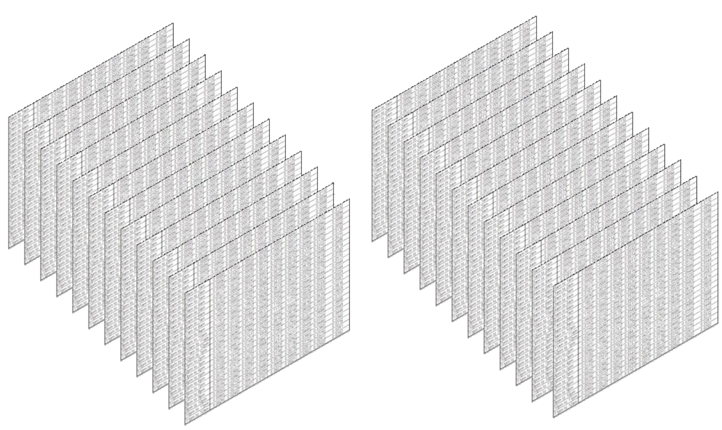
- Convert the GIS layer of the travel demand model to mesoscopic format
- Disaggregate 24-hour matrix based upon car & truck
  - Home to work
  - Work to home
  - Home to private
  - Private to home
  - Thru
  - External local
  - Non-home based external local
- Multiply each matrix by corresponding hourly factor

Network Conversion



Summation of matrices gives you directional 1-hour matrix

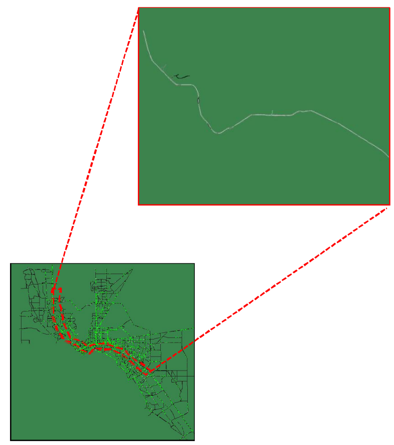
Network Conversion



24 – one hour matrices

Network Conversion

- Network run to DUE
- Sub-area cut
  - Remove unneeded sections of network
  - Renumbering of new zones, nodes and links
  - Retain paths and flows that travel through the sub-area

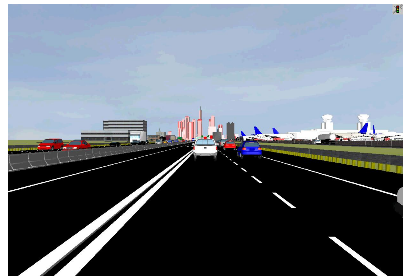


Network Conversion

- Meso-Micro Converter
  - Developed by researchers from TTI and UA
  - Converts roadway network to Macro network
  - Retains network geometry
  - Converts all time-dependent paths and flows
  - Creates separate transportation systems (car, truck)

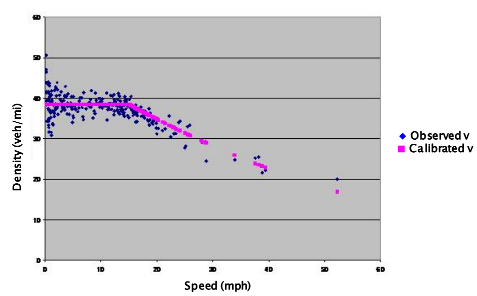
Network Conversion

- Microscopic model
  - Calibrate Micro model to reflect realistic roadway conditions
  - Perform detailed "fine-grained" analyses
    - Speed profile for individual lanes
    - Lane-changing behaviors
    - Vehicle interactions at merge areas
  - Create 3-D graphics for presentations



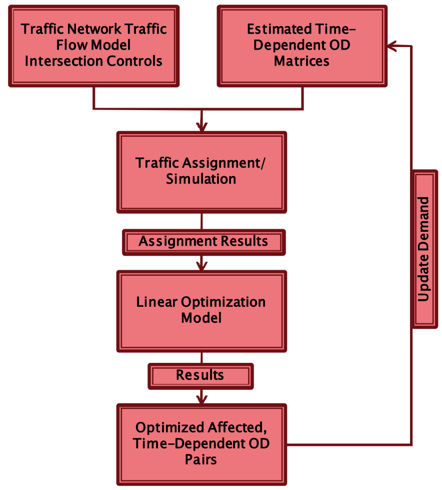
Calibration

- Traffic flow model
  - Traffic simulation in DynusT is based upon the Anisotropic Mesoscopic Simulation (AMS) model
  - Moves vehicle based upon speed-density (v-k) relationship
  - v-k relationship is derived from Greenshields equation



Calibration

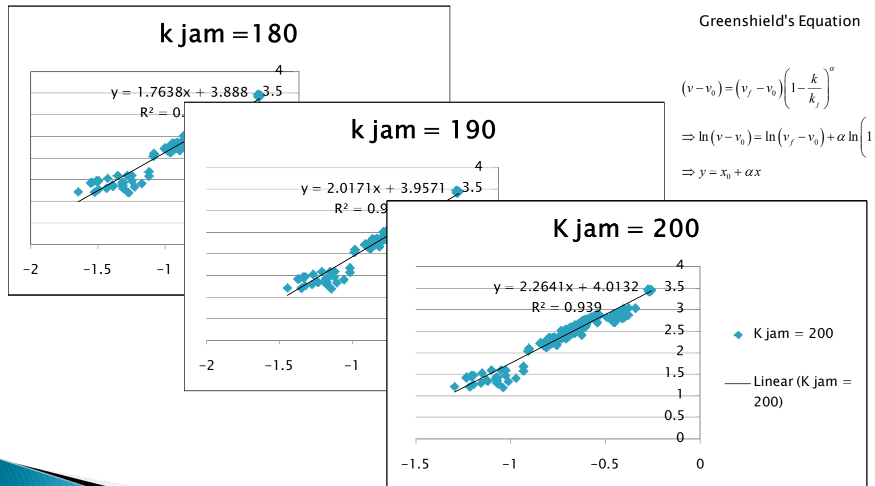
- Time-dependent OD
  - Minimize the deviation between simulated and actual screen line counts & speed profile
  - Iterative process
  - Program solves linearized quadratic minimization problem
  - Results in updated OD matrices



Consistency

- Network
  - Lane configuration
  - Geometric design
- Paths and flows
  - Verify same origin/destination paths
  - Verify number of vehicles generated
- Speed profile
  - Perform field data collection to determine speed and vehicle counts
  - Obtain v-k curve from simulation output
  - Calibrate models with field data

Consistency



Greenshield's Equation

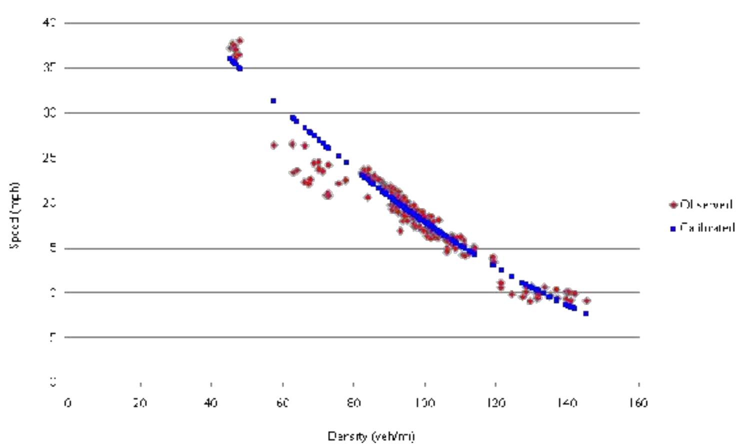
$$(v-v_0)=(v_f-v_0)\left(1-\frac{k}{k_j}\right)^{\alpha}$$

$$\Rightarrow \ln(v-v_0)=\ln(v_f-v_0)+\alpha\ln\left(1-\frac{k}{k_j}\right)$$

$$\Rightarrow y=x_0+\alpha x$$

The density at which traffic stops

Consistency



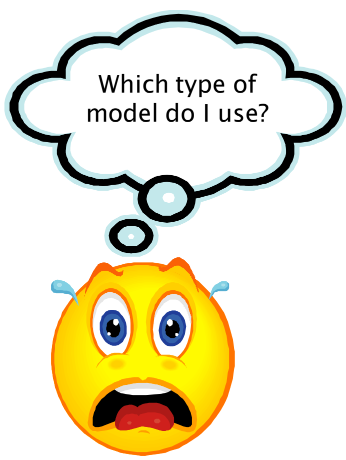
Speed Profile Calibrated with field data

Case Study 1

City Council proposes ordinance to restrict trucks from using left lane on I-10 corridor

How does the ordinance affect the freeway and surrounding arterials?

Case Study 1

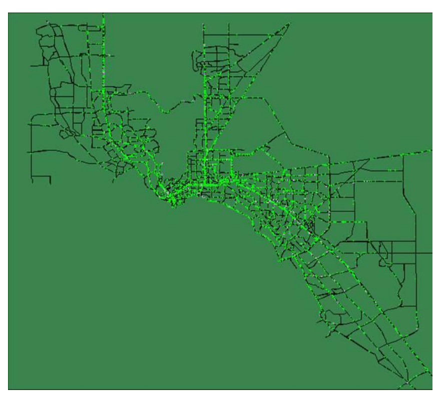


Case Study 1

- Truck restricted lanes
  - A case study to analyze the effectiveness of restricting trucks from left-most fast lane on freeway
  - 22-mile corridor of I-10 in El Paso, TX
  - Analyze a.m. peak, p.m. peak, & mid-day
  - Determine benefits
    - Speed on left-most lane
    - Acceleration/Deceleration patterns
    - Vehicle interactions at merge areas
  - DTA model estimates region-wide truck trajectories (route and flows)
  - Micro model- detailed IH-10 truck lane operations given truck trajectories

Case Study 1

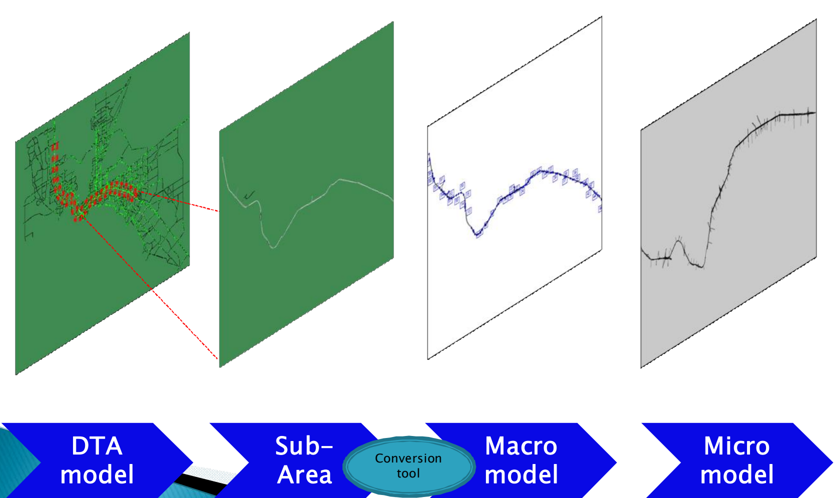
- Simulate entire El Paso network to equilibrium conditions
- Use separate demand matrices for auto & truck



Case Study 1

- Sub-area cut of corridor was extracted
- Conversion tool was used to translate the roadway network, paths & flows to macro model
- Using macro models export capability, a microscopic simulation model was imported to microscopic format

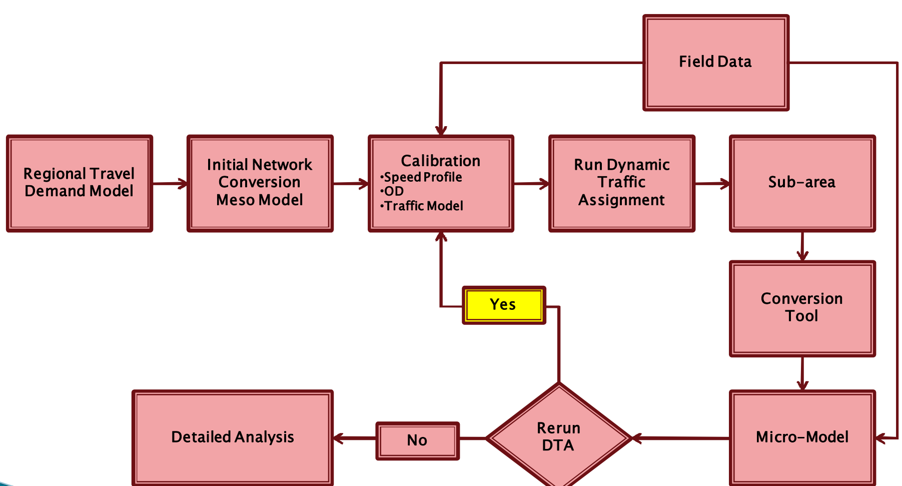
Case Study 1



Case Study 1

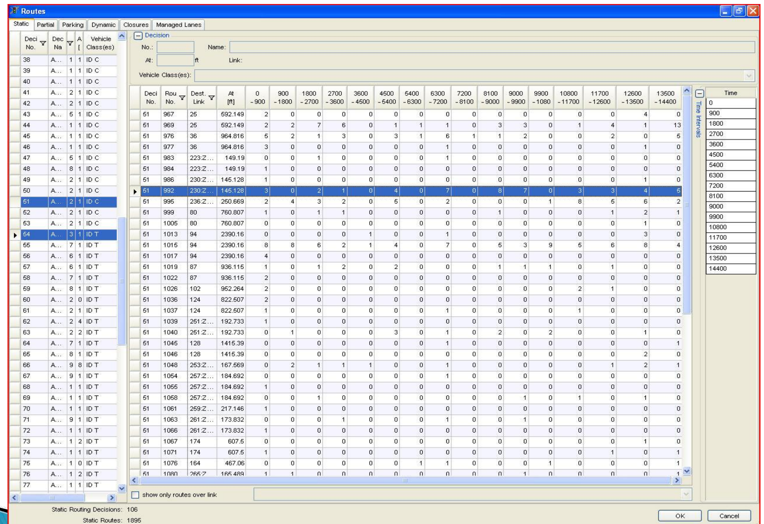
- If modifications in the VISSIM model change driver behavior (alters routes), changes must be reflected in DTA model and conversion process begins again.
- If no additional changes are needed, VISSIM model development begins

Case Study 1



Freeway missing auxiliary lanes

Case Study 1



106 Origin/Destination links – 1895 Routes created

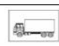
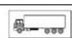
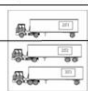
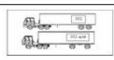
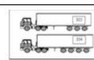
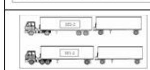
Case Study 1

Valid data A=valid test,GPS ok V= first valid sentence after	Latitude (ddmm.mmm) OR (dd.ddddd)	North/South	Longitude (dddmm.mmm) OR (dd.ddddd)	East/West	Time UTC (hhmmss)	Date (ddmmyy)	Speed (mph) (000.0-114.9)	Heading-Degrees (000-259)	Altitude (ff.f) OR (mm.m)	HDOP (00.5-99.9)	Satellites (00-12)
D	31.77808	N	106.4551	W	201014	60808	59.6	90	3707	0.8	12
D	31.77808	N	106.45482	W	201015	60808	59.6	90	3707	0.8	12
D	31.77808	N	106.45453	W	201016	60808	59.7	90	3707	0.8	12
D	31.77807	N	106.45425	W	201017	60808	59.7	90	3707	0.8	12
D	31.77807	N	106.45397	W	201018	60808	59.6	90	3707	0.9	12
D	31.77807	N	106.45368	W	201019	60808	59.3	90	3707	1	12
D	31.77807	N	106.4534	W	201020	60808	58.9	90	3711	0.8	12
D	31.77807	N	106.45313	W	201021	60808	58.4	90	3714	0.8	12
D	31.77807	N	106.45285	W	201022	60808	57.8	90	3714	0.8	12
D	31.77807	N	106.45258	W	201023	60808	57.4	90	3717	0.8	12
D	31.77807	N	106.45232	W	201024	60808	57.1	90	3720	0.8	12
D	31.77807	N	106.45205	W	201025	60808	56.6	90	3720	0.8	12
D	31.77807	N	106.45178	W	201026	60808	56.5	90	3724	0.8	12
D	31.77805	N	106.45152	W	201027	60808	56.8	91	3724	0.8	12
D	31.77805	N	106.45125	W	201028	60808	56.8	92	3727	0.8	12
D	31.77803	N	106.45098	W	201029	60808	56.9	93	3727	0.9	12
D	31.77802	N	106.45072	W	201030	60808	56.9	94	3727	0.9	12
D	31.77798	N	106.45045	W	201031	60808	56.8	95	3727	0.8	12
D	31.77797	N	106.45018	W	201032	60808	57.3	97	3727	1.3	12
D	31.77793	N	106.4499	W	201033	60808	57.3	98	3727	0.8	12
D	31.77788	N	106.44963	W	201034	60808	57.6	99	3724	0.8	12
D	31.77785	N	106.44937	W	201035	60808	58.1	100	3724	0.9	12
D	31.7778	N	106.4491	W	201036	60808	58.2	100	3720	0.8	12
D	31.77777	N	106.44883	W	201037	60808	58.4	100	3720	0.8	12
D	31.77772	N	106.44855	W	201038	60808	58.8	100	3717	0.8	12
D	31.77767	N	106.44828	W	201039	60808	58.9	100	3717	0.9	12
D	31.77763	N	106.448	W	201040	60808	59	100	3717	0.9	12
D	31.7776	N	106.44773	W	201041	60808	59.1	99	3717	0.9	12
D	31.77757	N	106.44745	W	201042	60808	59.5	98	3717	0.9	12
D	31.77753	N	106.44717	W	201043	60808	59.8	96	3714	0.9	12
D	31.7775	N	106.44688	W	201044	60808	60.1	95	3714	0.9	12
D	31.77748	N	106.4466	W	201045	60808	60.4	94	3714	0.9	12
D	31.77748	N	106.44632	W	201046	60808	60.4	92	3714	0.9	12
D	31.77747	N	106.44603	W	201047	60808	60.4	91	3714	0.9	12
D	31.77747	N	106.44575	W	201048	60808	60.5	90	3714	0.9	12
D	31.77747	N	106.44547	W	201049	60808	60.6	90	3714	0.9	12
D	31.77747	N	106.44518	W	201050	60808	60.5	90	3714	0.8	12

Complete I 10 Corridor_EB & WB

GPS unit was used to input freeway grading information

Case Study 1

Typical Vehicle Type	Texas 6 Classification	FHWA Classification
	**Class 5**: 3 axles, single unit	**Class 6**: 3 axles, single unit
	**Class 6**: 4 or more axles, single unit	**Class 7**: 4 or more axles, single unit
	**Class 7**: 3 axles, single trailer	**Class 8**: 3 to 4 axles, single trailer
	Class 8: 4 axles, single trailer	
	**Class 9**: 5 axles, single trailer	**Class 9**: 5 axles, single trailer
	**Class 10**: 6 or more axles, single trailer	**Class 10**: 6 or more axles, single trailer
	**Class 11**: 5 or less axles multi-trailers	**Class 11**: 5 or less axles, multi-trailers
	**Class 12**: 7 or more axles multi-trailers	**Class 12**: 6 axles, multi-trailers
	**Class 13**: 6 axles, multi-trailers	**Class 13**: 7 or more axles, multi-trailers

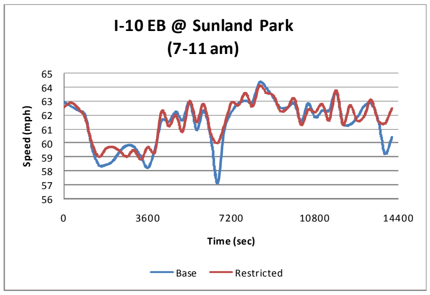
Truck Class	VISSIM Truck/Trailer	Truck Composition	Length (ft)	Shaft Length (ft)	Front Clutch (ft)	Front Axle (ft)	Rear Axle (ft)	Rear Clutch (ft)
5	truckUS_1.v3d	0.5	27.89	1.21	1.21	2.91	23.58	26.07
	truckUS_5.v3d	0.5	27.89	0.56	0.56	2.15	21.28	23.08
6	truckUS_1.v3d	0.5	27.89	1.21	1.21	2.91	23.58	26.07
	truckUS_5.v3d	0.5	27.89	0.56	0.56	2.15	21.28	23.08
7	truck1.v3b	1	18.25	0.00	0.00	5.18	15.39	13.60
	trail3b.v3b		21.66	0.00	4.32	4.33	17.90	21.47
8	truckUS2.v3d	1	16.40	0.85	0.85	2.25	14.06	12.32
	trail4.v3d		28.23	0.00	4.43	4.43	24.51	27.97
9	truckUS.v3d	1	20.67	0.00	0.00	2.27	18.23	16.61
	trailerUS3.v3d		47.57	0.00	3.96	40.85	43.97	46.14
10	truckUS_3.v3d	1	20.67	0.00	0.00	2.27	18.23	16.61
	trailerEuro1.v3d		42.65	0.00	3.87	3.87	32.05	41.41
11	truck1.v3b	1	18.25	0.00	0.00	5.18	15.39	13.60
	trail4.v3d		28.23	0.00	4.43	4.43	24.51	27.97
	trail3a.v3d		12.24	0.33	0.33	9.70	9.73	9.76
	trail4.v3d		28.23	0.00	4.43	4.43	24.51	27.97
12	truckUS3.v3d	1	20.67	0.00	0.00	2.27	18.23	16.61
	trail4.v3d		28.23	0.00	4.43	4.43	24.51	27.97
	trail3a.v3d		12.24	0.33	0.33	9.70	9.73	9.76
	trail3b.v3b		21.66	0.00	4.32	4.33	17.90	21.47
13	truckUS3.v3d	1	20.67	0.00	0.00	2.27	18.23	16.61
	trailerUS_3.v3d		47.57	0.00	3.96	40.85	43.97	46.14
	trail3a.v3d		12.24	0.33	0.33	9.70	9.73	9.76
	trail4.v3d		28.23	0.00	4.43	4.43	24.51	27.97

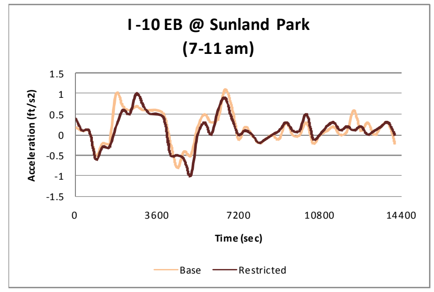
Data provided by TxDOT Automatic Traffic Recorder Stations

Case Study 1

Truck Class	Relative Flow	Length (ft)	Width (ft)	Weight (lb)		Power (hp)	
				Min.	Max.	Min.	Max.
5	0.082	27.89	8	15,000	46,000	220	260
6	0.009	27.89	8	20,000	53,000	220	300
7	0.001	30.94	8	25,000	52,000	250	300
8	0.019	36.13	8	28,000	66,000	315	380
9	0.835	60.22	8	30,000	80,000	380	480
10	0.006	55.39	8	32,000	87,000	415	490
11	0.039	70.69	8	35,000	92,000	440	500
12	0.009	67.24	8	35,000	106,000	505	525
13	0	92.35	8	35,000	120,000	570	580

Case Study 1 – Results

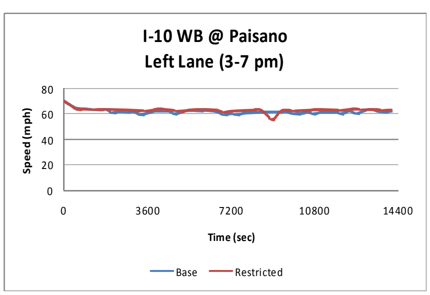


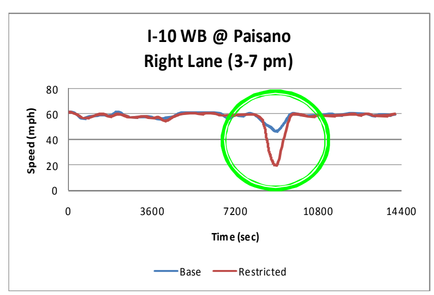


Speed

Accel/Decel

Case Study 1 – Results





Speed – Left vs. Right Lane

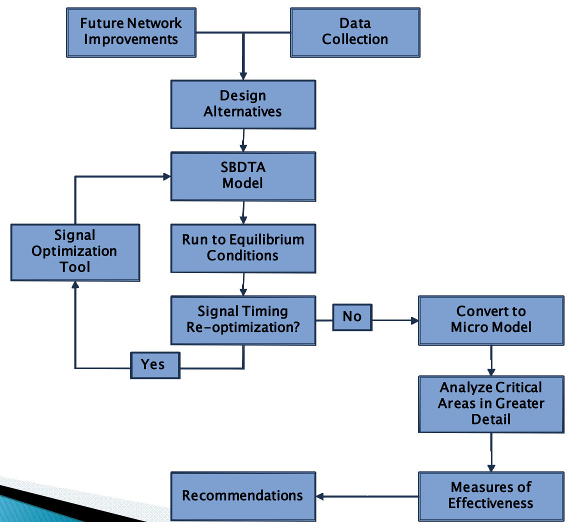
Case Study 2

- Texas Department of Transportation looking at alleviating congestion at diamond interchange and surrounding arterials in El Paso, TX.
- Propose 7 different design alternatives for direct connects
- Two sets of designs are identical except for direct connect lane access
- Corridor has heavy truck usage

Case Study 2

- TxDOT wants to know which alternative is most viable option?
- How does weaving at merge areas affect traffic on I-10?
- Analyze both the localized traffic impact and regional traffic redistribution
- Which model do you use?
  - Travel demand model?
  - Mesoscopic DTA model?
  - Microscopic model?

Case Study 2



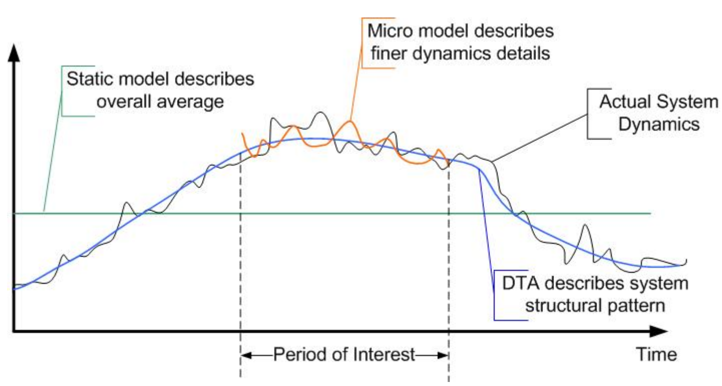
Case Study 2

- DTA model was able to show shifts in traffic based upon each design alternative.
  - Queuing on arterials and frontage roads
  - Speed fluctuations during peak hours
- Micro model was able to identify “hot-spot” areas where direct connects merge
- Micro model was used to determine whether or not grade played a major role on trucks entering freeway.

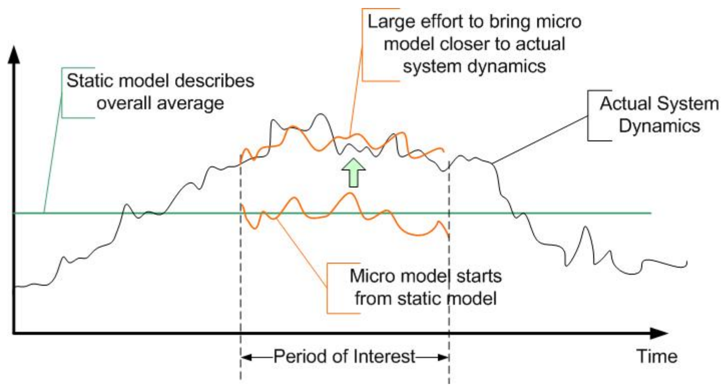
Other Issues

- Why don't we just convert from the travel demand model directly to micro model?
  - Travel demand model can give you a v/c ratio >1
  - This is not realistic
  - DTA model has capacity constraints on links
  - Will reroute excess flow to alternative routes based upon shortest travel time

Other Issues



Other Issues



Applications

- Managed lanes
  - Truck restricted lanes
  - HOV lanes
  - HOT lanes
  - Variable pricing

Applications

- Geometric design alternatives
  - Freeway direct connect
    - Various design configurations
  - Ramp reconfiguration
    - Braided ramps
    - “X” ramps

Applications

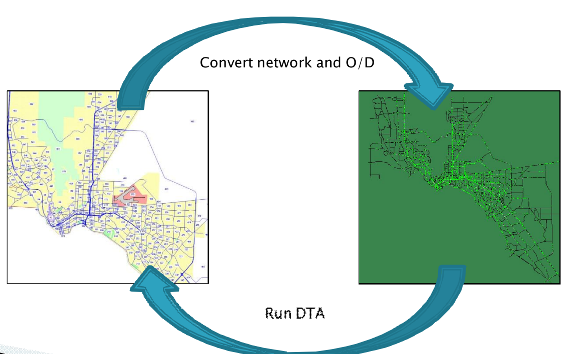
- Traffic impact studies
  - New retail shopping centers
    - Driveways
    - Pedestrian crossings
  - University campus planning
    - Integrating various modes of transportation (e.g. student, faculty, staff, pedestrians, transit)
    - New parking facilities
    - Campus core closure
  - Traffic calming

Concept – Macro to Meso

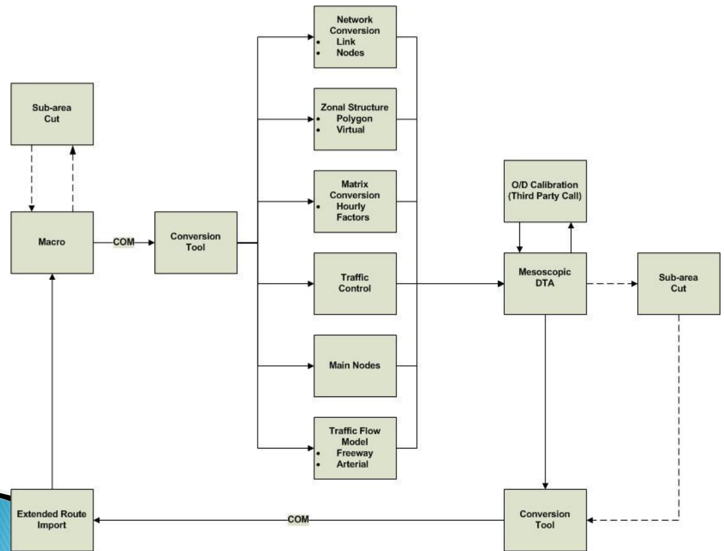
- MPOs across the country are starting to realize the need for more than just static simulation results
- DTA integrated with macro models can analyze at the regional level temporally and spatially
- Links on meso model are capacity constrained
  - In reality, volume cannot exceed capacity on roadways

Concept – Macro to Meso

- Macro to Meso
  - Used for regional planning where meso model runs dynamic traffic assignment

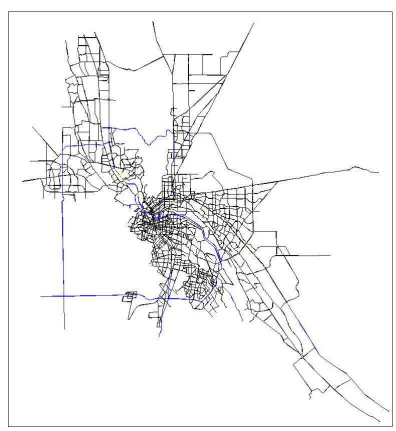


Concept – Macro to Meso



Scenario

- El Paso MPO has bi-national travel demand model for the El Paso/Juarez border region
- City to propose new Port-of-Entry to alleviate congestion, especially during afternoon commutes across the border.



Scenario

- What will the impact of new POE be on existing border crossings during peak hours?
- How can you analyze queue length caused by inspections?
- What if there is an incident that shuts down the bridge for several hours?

Thank You

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